Energy Research and Development Division
FINAL PROJECT REPORT

# SACRAMENTO MUNICIPAL UTILITY DISTRICT SCADA RETROFIT

Prepared for: California Energy Commission
Prepared by: SMUD SmartSacramento®

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## FEDERAL DISCLAIMER

# PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The Energy Research and Development Division conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The Energy Research and Development Division strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

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- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Supervisory Control and Data Acquisition (SCADA) Retrofit Project Report is the final report for the SCADA Retrofit Project (Agreement number PIR-10-034) conducted by the Sacramento Municipal Utility District (SMUD). The information from this project contributes to Energy Research and Development Division's Energy Systems Integration Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at [www.energy.ca.gov/research/](http://www.energy.ca.gov/research/) or contact the Energy Commission at 916-327-1551.

# ABSTRACT

The Sacramento Municipal Utility District (SMUD) Smart Grid project, SmartSacramento ®, consists of more than 40 individual projects that have been carried out over a four-year period, since 2010. These projects were broken up into seven major categories: Advanced Metering Infrastructure, Consumer Behavior Study, Demand Response, Customer Applications, Distribution Automation, Technology Infrastructure, and Cyber Security. SMUD's SmartSacramento® project was partially funded by the Department of Energy under the American Reinvestment and Recovery Act. The California Energy Commission Research and Development Program funded a portion of the Supervisory Control and Data Acquisition (SCADA) Retrofit project contained within SMUD's distribution automation efforts.

SMUD distribution system is currently comprised of 221 distribution transformers serving approximately 592,000 customers. The primary distribution system voltages include 21 kilovolt (kV) and 12kV. The 12kV system represents the majority of SMUD's distribution system and is served from a 69kV sub-transmission system running throughout the service territory. The 21kV system is comprised of five 115kV/21 kV substations, with 32 feeders serving the downtown Sacramento region. The 12kV downtown network system is served from two 115kV/12kV substations.

At the substations where SCADA was unavailable, only monthly load readings were taken by field personnel. System engineers and operators then had to make system assumptions based on non-coincident and insufficient load data. In addition, equipment temperature, power flow information, and coincident feeder data were unavailable for analysis. Installing SCADA allowed collecting circuit load data, voltage levels, volt-ampere reactive flow, and transformer loading at these substations. This enables SMUD system engineers to fully and effectively use system capacity and resources. Substation SCADA retrofits coupled with other integral smart grid tasks are expected to reduce outage cost, lower distribution losses, lower electricity use, and reduce greenhouse gas emissions.

**Keywords:** SMUD, Smart Grid, SmartSacramento, distribution system, Advanced Metering Infrastructure, Consumer Behavior Study, Demand Response, Customer Applications, Distribution Automation, Technology Infrastructure and Cyber Security

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# EXECUTIVE SUMMARY

The Sacramento Municipal Utility District (SMUD) Smart Grid project, SmartSacramento®, consists of more than 50 individual projects that have been carried out over a four-year period, since 2010. These projects were broken up into seven major categories: Advanced Metering Infrastructure, Consumer Behavior Study, Demand Response, Customer Applications, Distribution Automation, Technology Infrastructure, and Cyber Security. Appendix B contains additional information on 42 of the SmartSacramento projects. SMUD's SmartSacramento® project was partially funded by the Department of Energy under the American Reinvestment and Recovery Act. The California Energy Commission Research and Development Program funded a portion of the SCADA Retrofit project contained within SMUD's distribution automation efforts.

SMUD's distribution system is currently comprised of 221 distribution transformers serving approximately 592,000 customers. Before completing this project, only half of these substations were Supervisory Control and Data Acquisition (SCADA) enabled, whereas, the other half did not have SCADA capability. The SCADA retrofit project cost about $16.9 million and upgraded forty distribution substation transformers increasing SMUD's SCADA enabled transformers to 70 percent. SMUD's current distribution automation plan is to install SCADA at all of its remaining 12kV distribution substations.

Installing SCADA will provide real-time equipment system status and enable system operators to remotely monitor and control substation equipment. It will improve reliability and quality of service as well as system efficiency and response time to outages. Asset management will also be improved and lost revenue from outages will be reduced. The SCADA will support SMUD's other automation initiatives such as the implementing an Advanced Operating System (AOS). The AOS enables Conservation Voltage Reduction (see Appendix 1), Volt/VAr Optimization, and Automatic Sectionalizing and Restoration.

The overall project has expanded and accelerated deploying an advanced smart grid technologies throughout the Sacramento region.

# CHAPTER 1: SCADA Description

For electric utility applications, SCADA (supervisory control and data acquisition) is typically comprised of software and hardware to remotely control distribution substations (Figure 1). The supervisory system is combined with a data acquisition system to acquire information about the status of substation equipment for use by distribution system operators or by a distribution management system. SCADA provides utility operators with a window into the substation, allowing them to see and control substation parameters that are important to the safe and reliable operation of the distribution system.

## 1.1 SCADA Components

The SCADA systems installed as part of this project consist of these subsystems:

- Remote terminal units (RTUs) connect to sensors that convert sensor signals to digital data. The digital data is then sent to the supervisory system, as well as receiving digital commands from the supervisory system.
- Programmable logic controllers (PLCs) connect to sensors and convert sensor signals to digital data. PLCs have more sophisticated embedded control capabilities than RTUs. PLCs are sometimes used in place of RTUs as field devices because they are more economical, versatile, flexible, and configurable.
- A telemetry system is typically used to connect PLCs and RTUs with control centers, data warehouses, and the enterprise.
- A data acquisition server allows clients to access data from these field devices using standard protocols.
- A human–machine interface or HMI presents processed data to a human operator, and through this, the human operator monitors and interacts with the process.
- A Historian (Pi) is a software service that accumulates time-stamped data, events, and alarms in a database, which can be queried or used to populate graphic trends in the HMI. The historian is a client that requests data from a data acquisition server.
- A supervisory (computer) system, gathering (acquiring) data on the process, and sending commands (control) to the process.
- Communication infrastructure connecting the supervisory system to the remote terminal units.
- Various process and analytical instrumentation.

## 1.2 System Overview

The term SCADA usually refers to centralized systems, which monitor and control industrial sites, or complexes of systems spread out over large areas. Most control actions are performed automatically by RTUs or by PLCs. Host control functions are usually restricted to basic overriding or supervisory level intervention. For example, a PLC may control the flow of electricity through a distribution feeder, but the SCADA system may allow operators to change the set points for electricity flow and enable alarm conditions, such as large fluctuations in power flow and transient power spikes, to be displayed and recorded. The feedback control loop passes through the RTU or PLC, while the SCADA system monitors the overall performance of the loop.

Data acquisition begins at the RTU or PLC level and includes meter readings and equipment status reports that are communicated to SCADA as required. Data is then compiled and formatted in such a way that a control room operator using the HMI can make supervisory decisions to adjust or override normal RTU (PLC) controls. Data may also be fed to a Historian, often built on a commodity Database Management System, to allow trending and other analytical auditing.

SCADA systems are significantly important in electric grids. However, SCADA systems may have security vulnerabilities, so the systems should be evaluated to identify risks and solutions implemented to mitigate those risks. SMUD has incorporated state-of-the-art systems and technologies to ensure the cyber security of the SCADA-enabled substations and the entire SMUD electrical system.

## 1.3 Human Machine Interface

A human–machine interface or HMI is the apparatus which presents process data to a human operator, and through which the human operator controls the process.

HMI is linked to the SCADA system's databases and software programs, to provide trending, diagnostic data, and management information such as scheduled maintenance procedures, logistic information, detailed schematics for a particular sensor or machine, and expert-system troubleshooting guides.

The HMI system presents the information to the operating personnel graphically. SMUD has implemented a Situational Awareness and Visual Intelligence (SAVI) project on a Google Earth platform to enable operators to use SCADA data and to see substation parameters real-time. The operator can then see a schematic representation of the substation or feeder being controlled. For example, an operator can pull up an image of an electrical feeder and see the loading on each phase of the feeder, the amps, historical information and more.

The SCADA system enables alarms system conditions. The system monitors whether certain alarm conditions are satisfied and determines when an alarm event has occurred. Once an alarm event has been detected, one or more actions are taken (such as the activation of one or more alarm indicators, and perhaps the generation of email or text messages so that management or remote SCADA operators are informed). In many cases, a SCADA operator may have to acknowledge the alarm event; this may deactivate some alarm indicators, whereas other indicators remain active until the alarm conditions are cleared. The role of the alarm indicator is to draw the operator's attention to the part of the system 'in alarm' so that appropriate action can be taken.

**Figure 1: SCADA system installation**

A finished SCADA system at one of the SMUD substations.

# CHAPTER 2: Activities Performed

## 2.1 Installation

Installing SCADA systems required design, modification, and installation of electrical, communication and DC power supply systems. It required replacing old electro-mechanical relays with new microprocessor relays and the installation of Intelligent Electronic Devices (IEDs). To reduce substation outage durations and keep the project on schedule and within budget, the installation process at each substation was completed in two stages. The first phase involved work that was completed without affecting the operation of the substation, however the second phase was completed by removing the substation from service. After testing the new systems and devices, the substations were re-energized and restored back to the SMUD system. A cooling fan was installed and heat reflective paint was applied to the enclosure housing relays and other devices to ensure operational efficiency and longevity of the equipment inside the enclosure (Figures 2 and 3).

**Figure 2: Before SCADA installation at one of 40 substations, receiving SCADA upgrades.**

**Figure 3: After SCADA installation.**


The two differences are applying reflective paint and installing a fan, both designed to keep the equipment cooler on hot summer days.

## 2.2 Upgrade

The SCADA retrofit project upgraded forty (40) 69kV/12kV distribution substation transformers to enable SCADA. The upgrades occurred on transformers that were not previously SCADA enabled. The new SCADA installations greatly improve operator control and reliability of the system. The Energy Commission contribution paid for the internal labor associated with the installation of SCADA functionality at four of the forty (40) 69kV/12kV distribution substation sites. A total of 9,736 labor hours were spent on the Energy Commission substations at Mather #1, Mather #2, Walerga Galbrath #1, and Whiterock Sunrise #1.

## 2.3 Achievement of Activities Performed

A total of 77,775 hours were spent completing the SCADA installations at all 40 substation transformers. The process took 3 1/2 years from planning through commissioning. With the completion of the 40 substations, SCADA functionality is available at 70 percent of SMUD's 69kV/12kV unit substations.

# CHAPTER 3: Expected Benefits

## 3.1 Benefits to SMUD

The Supervisory Control and Data Acquisition (SCADA) retrofit provides real-time equipment system status and enables system operators to remotely monitor and control substation equipment. It improves reliability and quality of service as well as system efficiency and response time to outages.

It will improve asset management by using the substation automation system to closely monitor the condition of the equipment within the substation, in order to maximize the capacity from existing equipment and enable more cost effective decisions concerning replacement of old and obsolete equipment.

The SCADA retrofit will reduce lost revenue from outages as the intelligent electronic devices will provide equipment monitoring features and will give advance warning of system problems to the operators, thus allowing them to react to the situation before transmission capability is lost resulting in a forced outage.

Substation automation makes preventive maintenance obsolete and allows changing to "condition based / risk based / or just in time maintenance" practices with the aid of condition monitoring capabilities.

The SCADA functionality supports SMUD's other automation initiatives such as the implementation of an Advanced Operating System (AOS). The AOS enables Conservation Voltage Reduction (CVR), Volt/VAr Optimization (VVO), and Automatic Sectionalizing and Restoration (ASR).

CVR and VVO are used in conjunction with each other. CVR uses the Load Tap Changer within the SCADA substation. Operators can remotely lower the voltage output at the substation while substation and line capacitor banks provide voltage support on the distribution lines. Initial tests have been conducted with the implementation of 2 to 3 percent voltage reduction. These voltage reductions have demonstrated energy savings (MWh) and reductions in demand (MW). Appendix A contains a brief summary of the initial VVO/CVR test. A second test is underway that includes 14 substations and 58 circuits.

When SCADA reports that a circuit breaker has locked out at one of the SCADA retrofit substations, ASR is triggered and begins to coordinate the automated switching devices on the lines to isolate the fault and re-route power. This is expected to result in an improvement of twenty percent (20 percent) System Average Interruption Duration Index (SAIDI) on the upgraded circuits.

## 3.2 Benefits to California

California utilities are implementing smart grid technologies on a broad scale. The smart grid will allow utilities to optimize the grid while installing thousands of distributed energy resources on the system. Reliability and efficiency will be improved as infrastructure is put in place to centrally manage these new resources.

SCADA plays a central role in the smart grid, allowing operators to see substation parameters in real-time. SCADA also enables conservation voltage reduction (CVR), which provides energy efficiency benefits to the utility and the customer, (Figures 4 and 5). SCADA benefits include:

- Improved reliability
- Improved quality of service
- Improved asset management
- Reduction in lost revenue due to outages
- Facilitates CVR

All of these benefits eventually roll up to California customers as fewer outages, shorter duration of outages, reduced utility costs (equates to lower customer costs) and energy efficiency through CVR that is invisible to the customer, but real nonetheless.

**Figure 4: SCADA Panel**

**Figure 5: SCADA Electrical Panels**

# CHAPTER 4: Advancement of Science & Technology

The overall project will expand and accelerate the deployment of advanced smart grid technologies throughout the Sacramento region. When complete, SmartSacramento® will: link smart meters and home area networks with upstream, automated distribution operations; optimize distribution system operations to improve system reliability and efficiency; and fully enable customers to participate in the electricity marketplace with the introduction of dynamic pricing and demand response programs. SCADA implementation is vital for attaining all of the program goals and objectives. While SCADA may be installed in other areas, it has not been widely studied in combination with such a wide variety of other smart grid projects.

The Distribution Automation (DA) set of projects demonstrates the installation of system automation controls (Figure 6). These include supervisory control and data acquisition (SCADA) retrofit of 40 substations (70 percent of the total number of substations) and intelligent switching and monitoring equipment at 128 12 kV feeders (19.5 percent of the total number of feeders), 18 - 21 kV feeders, and 25 - 69 kV sub-transmission feeders (44 percent of the total number of sub-transmission feeders). The set of projects also includes the developing and installating advanced operating system (AOS) functionality for volt-VAR optimization (VVO) and automatic sectionalizing and restoration (ASR) for feeders. In addition to the equipment installations and retrofits that are the backbone of the DA project set, SMUD included several projects to improve outage communications to its customers and to increase the operational efficiencies of the workforce in the command center, as well as their field forces. All of the DA projects are shown in Figure 7.

**Figure 6: Distribution Automation Schemtic**

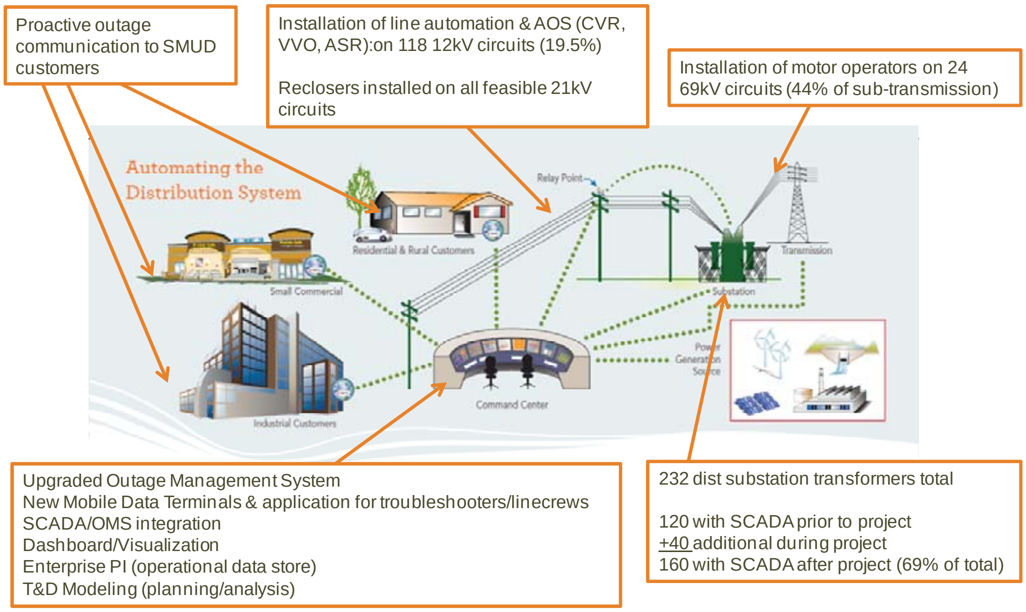
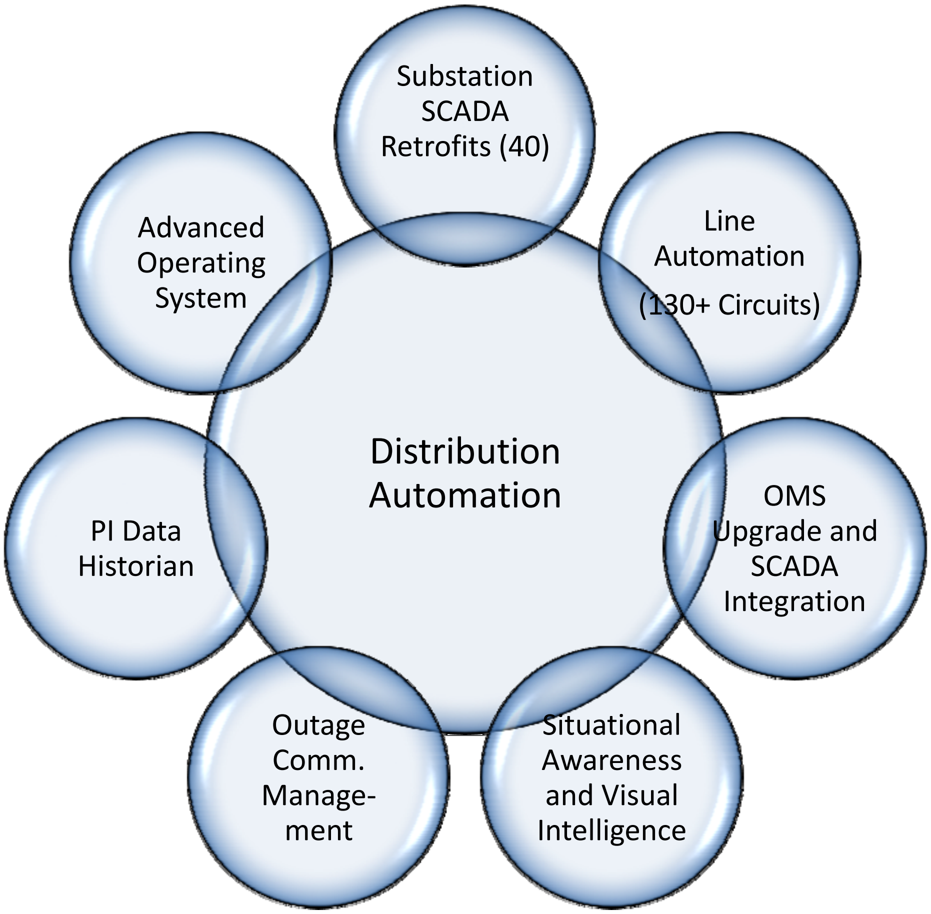


**Figure 7: Distribution Automation Projects**




The DA-related projects will enhance operating capability, increase system efficiency, improve reliability (an estimated 25 percent reduction in the annual System Average Interruption Duration Index [SAIDI] on the 69 kV circuits and 20 percent reduction in annual SAIDI for 12 kV and 21 kV circuits for feeder outages only), lower electricity use and flatten load curve (estimated 36,520 MWh/yr, 0.4 MW peak load reduction), optimize distribution network (estimated 11,150 MWh/yr, 6.2 MW peak load reduction), and lower electricity use and lower T&D losses, resulting in a reduction in greenhouse gas (GHG) of 38.1 million pounds.

The overall project will enable collecting circuit load data, voltage levels, VAR flow, and transformer loading. Full SCADA automation will allow the system engineering group to completely and effectively use system capacity. It will enable the interoperability between the Energy Management System (EMS) and an upgraded Outage Management System (OMS), which will optimize the distribution system via CVR, VVO, and future integration with smart meter systems (UIQ and the meter data management system).

# CHAPTER 5: Project Performance

## 5.1 Project Scope

- Planned work: Retrofit of 40 distribution substation transformers
- Project design: Determined project scope, design parameters, system requirements and budget
- SCADA Procurement: Procured SCADA through established SMUD procurement processes and in conformance with DOE requirements
- Construction: Installed new equipment using trained installers and established processes and procedures
- Commissioning and Closeout: Commissioned all new installations to ensure proper operation
- Actual completed work: Retrofit of 40 distribution substation transformers

## 5.2 Project Schedule

- Project Planning — April 2010 – September 2010
- Procurement — October 2010 – September 2012
- Civil Design and Telecom Construction — January 2010 – June 2012
- Electrical Construction — November 2010 – December 2012
- Project Completion — December 2012
- Project close-out — January 2013 - April 2013

## 5.3 Project Budget

With the completion of these forty substations, SCADA functionality is available at 70 percent of SMUD’s 69kV/12kV unit substations. SMUD's current distribution automation plan is to install SCADA at all of its remaining 12kV distribution substations (Figure 8).

**Figure 8: SCADA Budget**

| Planned Budget | Actual Cost | Variance |
|---|---|---|
| $16,526,891 | $16,943,636 | 2.5% |

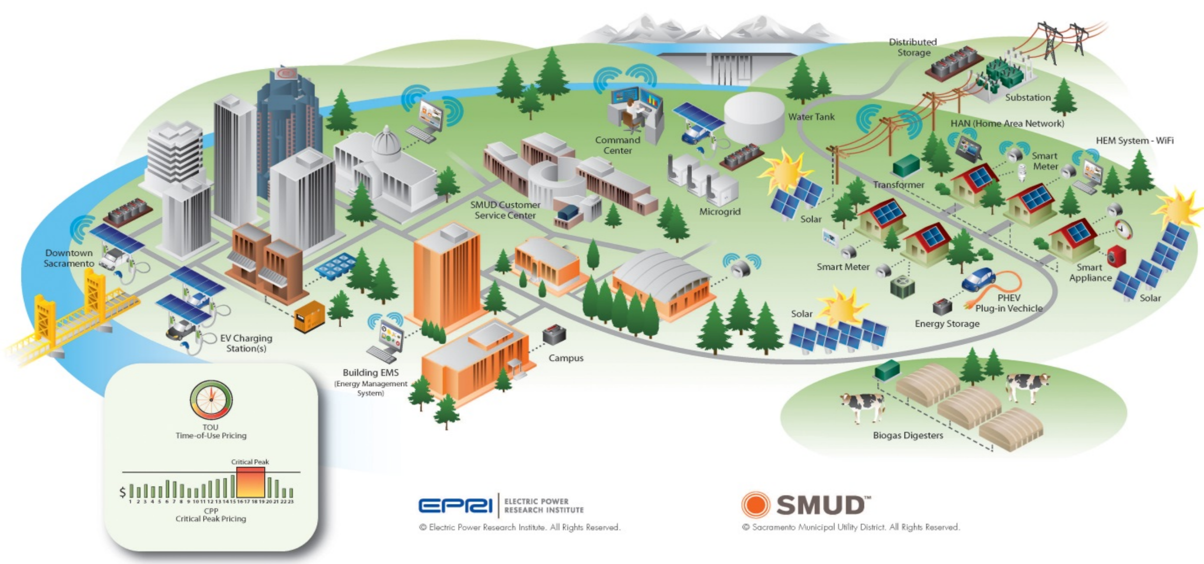
# CHAPTER 6: Conclusions

SCADA implementation provides utility operators with the real-time information they require to monitor and control substation transformers. SCADA also provides real-time equipment status. SCADA supports or enables several additional components that improve grid reliability and efficiency. These advanced operating system elements include:

- Volt VAr Optimization
- Conservation Voltage Reduction
- Automatic Sectionalizing and Restoration

SCADA is an essential part of the smart grid and should be employed in all large and critical substations. Cost-benefit analyses should be run on smaller substations and all cost-effective projects should be installed.

# APPENDIX A: VVO/CVR Case Study




## SMUD Case Study on Conservation Voltage Reduction

In 2011, SMUD conducted a conservation voltage reduction (CVR) test on six feeders to determine energy savings as well as peak demand reduction. The feeders are served from the Madison-Kenneth and Myrtle Date 69/12 kV substations. A test of new volt-VAR optimization (VVO) software was also performed.

This test entailed the following system enhancements: the installation of new switched capacitor banks, addition of new capacitor controllers with two-way radio communications, implementation of new VVO software (an enhancement to an existing system called Capcon), modification to the voltage settings and local override control for the load tap changer (LTC) controllers, and implementation of the CVR control capability with the existing Siemens SCADA system.

In order to test both the CVR and VVO benefits, SMUD carefully designed the tests so that there were days when only CVR or VVO was implemented, days when both were enforced, and days when neither was active. CVR tests were conducted at three different voltage reduction levels (CVR Level 1-3). Each level represented a corresponding percentage voltage reduction set-point change in the LTC on the power transformer.

1 percent CVR: 1 percent Reduction in set-point voltage

- 2 percent CVR: 2 percent Reduction set-point voltage (most tests were performed at this level)
- CVR Level 3: 3 percent Reduction in set-point voltage

The tests were performed during August and September to determine the maximum benefits of these programs during the summer months.

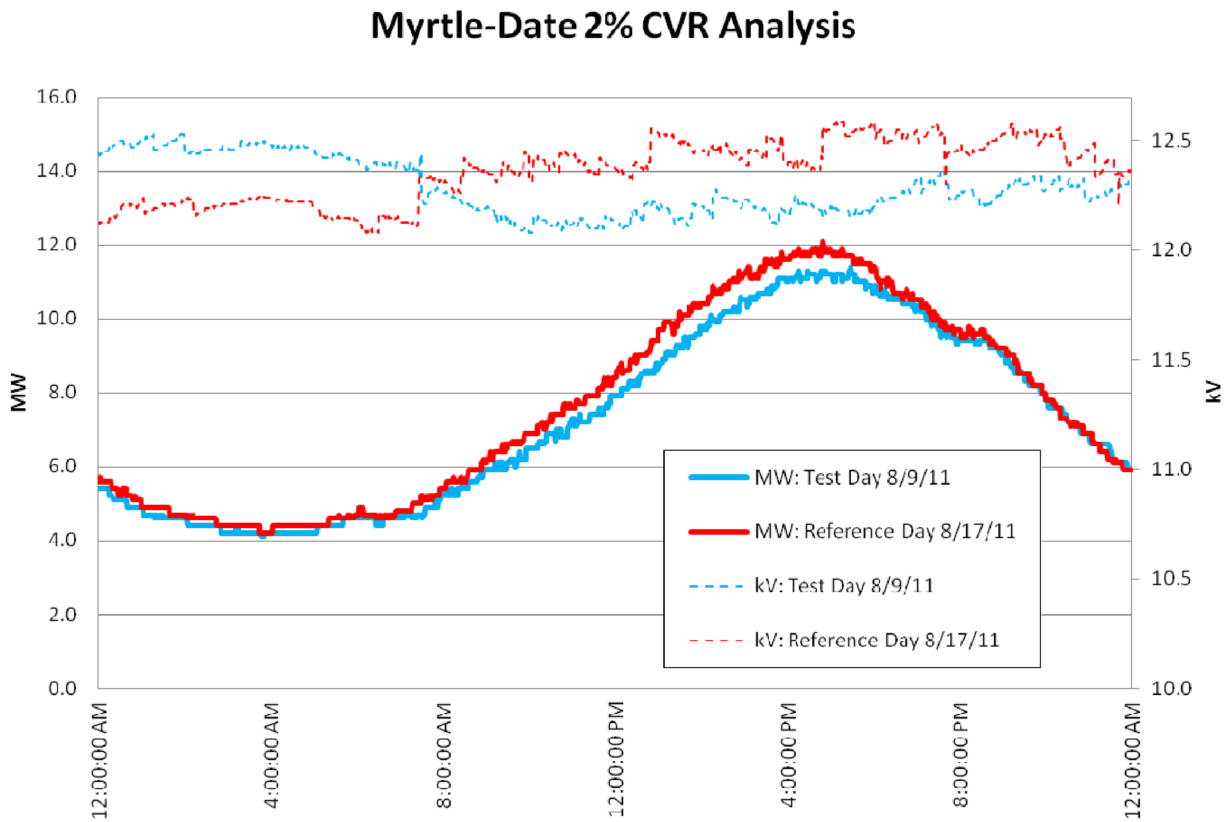
## Project Hypotheses

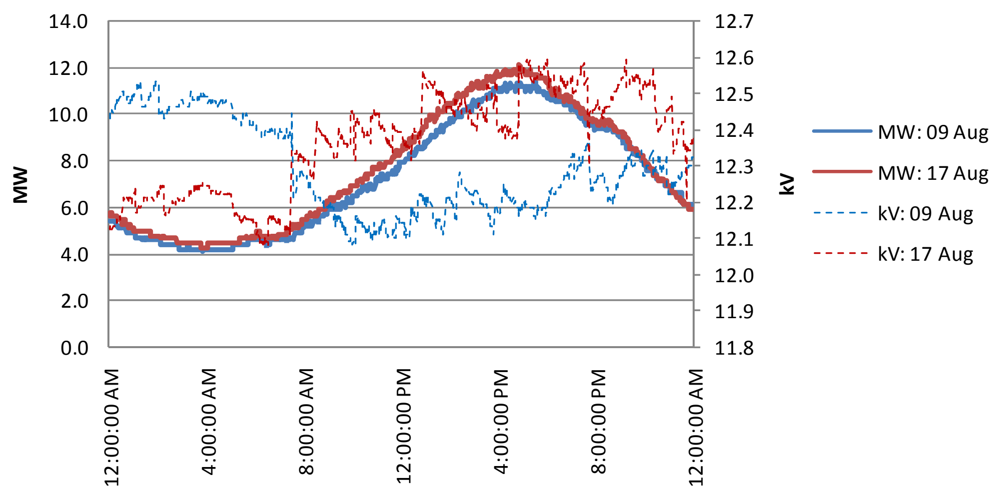
The following are the hypotheses for the CVR/VVO project:

- Capcon control logic can be modified to incorporate control of distribution line capacitor banks to maintain power factor to within an acceptable range.
- Control logic and communications can be used to control the voltage reduction level on the LTC controller from the distribution operations center.
- Demand reduction and energy savings increase as the normal level of voltage is reduced by 1-3%.
- Proper reactive power management on a substation results in less system losses.

## Results

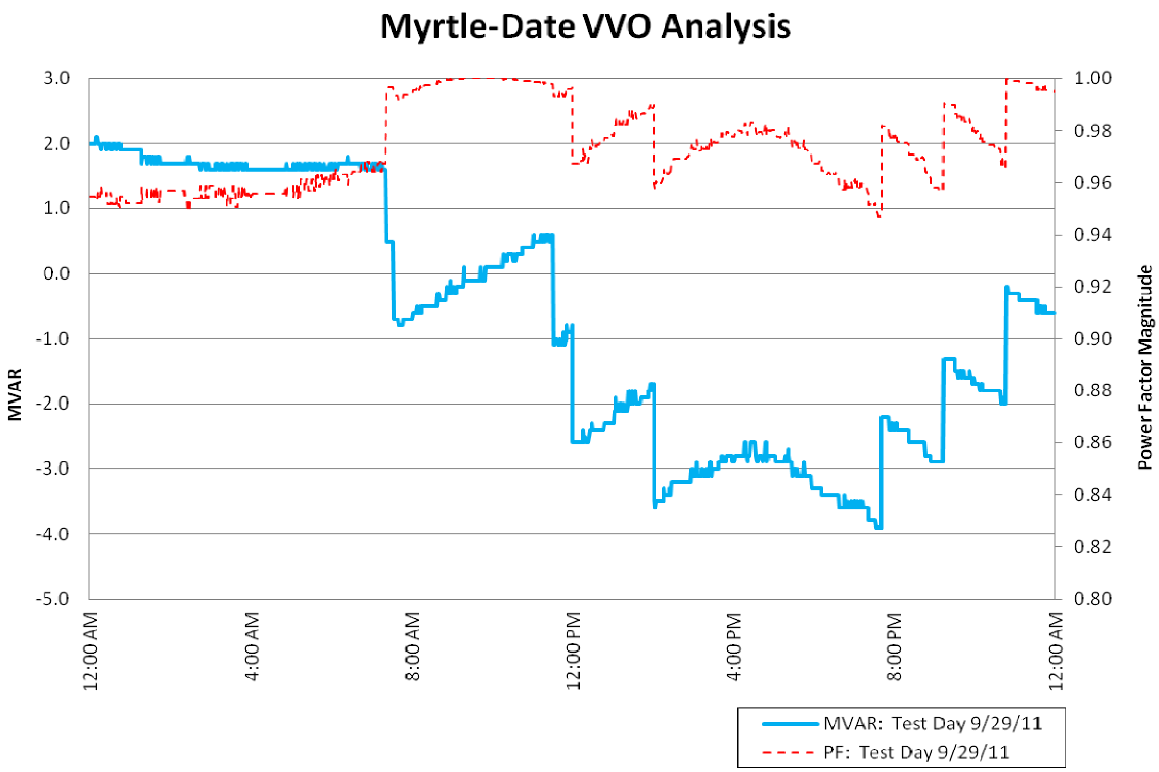
The CVR control logic was extensively demonstrated through the test period on the two substations. On average, the approximate demand reduction for a 2 percent voltage reduction or a 2 percent CVR test was 2.5 percent for the Myrtle-Date substation and 1 percent for the Madison-Kenneth substation. The plot below shows an example 2 percent CVR test on August 9th compared to the reference day of August 17th. The comparison of the dotted lines shows the marked reduction in voltage that resulted from the CVR implementation. The blue dashed line shows the voltage being reduced around 8:00am. The red dashed line shows the voltage returning to normal at the same time on the non-test day. The solid red and blue lines show the corresponding reduction in demand between the test day and the non-test day loading.

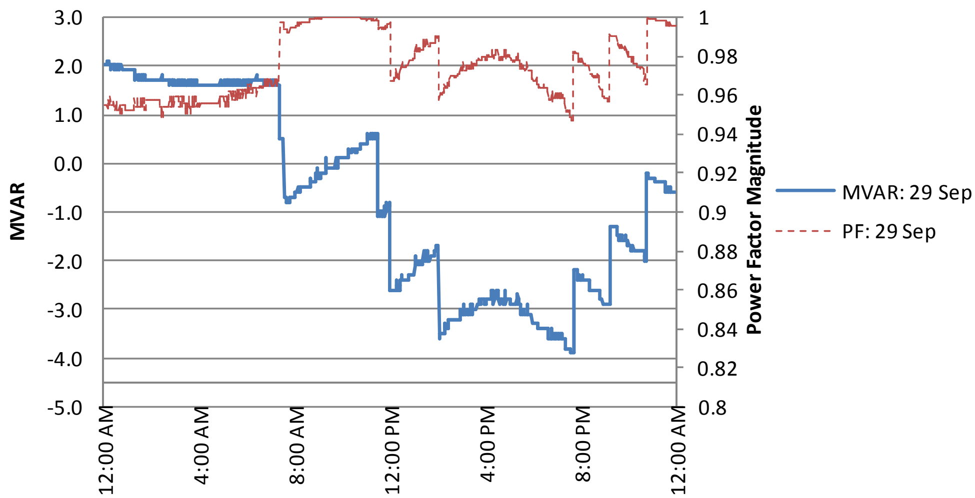



One 3 percent CVR (3 percent voltage reduction) test showed an additional reduction of 350kW, approximately 3 percent beyond the reduction realized from 2 percent CVR implementation. This indicates a total demand reduction for 3 percent CVR on the order of 5 percent for this single instance. Additional 3 percent CVR tests are planned for 2013 to confirm whether or not similar voltage reductions are observed over numerous tests.

The VVO control logic was demonstrated during the testing and the changes in the control logic confirmed via measurement. The final control logic maintained overall power factor between 0.95 leading and unity on the low side of the substation transformer for both the Madison-Kenneth and Myrtle-Date substations and is expected to be able to be successfully extended to the SCADA retrofit substations planned for 2012 and 2013. An example of the power factor and MVAR during testing is shown in the plot below.




*Myrtle - Date VVO Example – Load Based Transformer kVAR Logic (23 Sep – 30 Sep)*

The loss minimization from VVO is of a magnitude that was not discernible based on the measurement resolution available. However, simulations consistently showed small loss benefits associated with control logic in addition to management of the power factor.

## Lessons Learned

- It was observed that the Carmichael 230kV voltage used for both Capcon and the VVO control logic generally indicated substantially lower than neighboring 230kV voltages. As a result, the VVO control logic often called for greater reactive compensation than would have been called for based on surrounding voltages. This greater reactive compensation resulted in a correspondingly greater leading power factor. As a result, SMUD modified the control logic to prevent the power factor from going beyond 0.97 leading.

- Testing of VVO on the Myrtle-Date circuits yielded reactive power being maintained within varying ranges as the control logic was altered during the test cycle. The sporadic inclusion of two distribution capacitor banks due to communication issues, and the switching of substation feeder capacitors that are 1800 kVAR rather than the line capacitors that are 1200 kVAR, resulted in a wide range of reactive power demands. This bandwidth is expected to narrow as the two capacitor banks are reliably included in the control logic and the control logic utilizes the variable transformer VAR demand.

- VVO enables efficient operation of the distribution system and provides voltage support necessary to implement CVR.

- Additional testing amongst a larger pool of substations is required in order to determine predictability of the CVR control strategy.

# APPENDIX B: SmartSacramento Fact Sheets

SmartSacramento®

2009 - 2014

August 2013

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## Cyber Security



## Research and Development

# SmartSacramento® Overview

In October 2009, The Department of Energy awarded SMUD a $127.5 million Smart Grid Investment Grant to implement a $308 million project. Additional grants were received for smart grid research and development projects, bringing the smart grid project total to almost $360 million. This series of grants kicked off an aggressive and comprehensive smart grid project for the Sacramento Municipal Utility District (SMUD), titled SmartSacramento. The project eventually included over 50 subprojects divided over eight project areas:

1. Advanced Metering Infrastructure (Smart Meters)
2. Distribution Automation
3. SmartPricing Options (Consumer Behavior Study)
4. Demand Response
5. Customer Applications
6. Technology Infrastructure
7. Cyber Security
8. Research and Development

This document contains individual fact sheets on 43 SmartSacramento projects. The fact sheets provide descriptions of the individual projects, including project features, expected benefits, and project manager contact information. Most of the projects are complete and the fact sheets accurately represent project details. A few projects are not complete. The associated fact sheets represent the current project status and may change over time.

# Smart Grid

## Smart Meters

### Project Overview

The SmartSacramento® initiative started with smart meters, which laid the foundation for a wide range of customer benefits and utility-scale advances. SMUD replaced more than 620,000 old meters with new smart meters capable of two-way wireless communication. During the installation process, customer satisfaction was a resounding 93 percent, and installation refusals were less than 0.4 percent, which was much lower than the 1 to 1.5 percent refusal rates for similar installations by other utilities.

Smart meters allow customers to see their daily and hourly energy usage on the Web. The meters also enable SMUD to remotely read usage and sets the stage for customers to use smarter thermostats, home energy management systems and smart appliances that maximize energy efficiency. Smart meters also provide the opportunity for variable pricing so customers can use electricity when prices are lower.

### Project Features

*Goals & Objectives*

The objectives of the project were to implement a smart meter system for all residential and commercial customers that would:

- Significantly reduce ongoing operational costs
- Enable SMUD to improve service to our customers


- Provide customers with new energy efficiency, demand response, and pricing programs
- Enable SMUD and our customers to reduce our impact on the environment
- Create a foundation on which we can build future smart grid functionality

*Design & Features*

- Landis+Gyr meters
- Silver Spring Networks two-way mesh network
- Acceptance testing of 78,000 meters, September 2011–December 2011

*Continued on back*

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- Smart Meters Communication Plan
- Full Deployment
- Transition to Operations

*Benefits*

- Reduces ongoing operations costs by approximately $14M per year
- Provides customers with hourly energy usage information via the Web
- Enables remote connection and disconnection of electricity
- Provides a platform to offer customers a choice of standard or time-of-use rates
- Integrates with customer-facing devices such as in-home displays, programmable controllable thermostats, and energy management systems that help customers better manage their energy usage
- Provides updated outage and restoration alarms that make it easier to respond to and resolve outages

## At-a-Glance Facts

*Project Components:*

- Meters: 620,000
- Access Points: 174
- Relays: 201

*Technology:*

- Meters: Focus AX (single-phase) and S4e (poly-phase) – Landis+Gyr
- 802.15.4 radios in all single-phase meters for home area networks
- Network & head end software: Access points & relays, utility IQ software – Silver Spring Networks
- Meter data management system: Itron's IEE
- Backhaul: AT&T wireless data

*"The foundation for a smart grid begins with a communications network and smart meters!"*

*— Erik Krause, Senior Project Manager*

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# Smart Grid

## Substation SCADA Installation

### Project Overview

Supervisory control and data acquisition (SCADA) enables real-time monitoring and control of the distribution substation transformers. SMUD's oldest distribution substations were installed prior to the availability of SCADA technology. Each year, SMUD budgets for the upgrade of a few of these older substations. The Substation SCADA Installation Project accelerated the upgrade plan, retrofitting 40 distribution substation transformers with SCADA. At the start of this project, there were 232 distribution substation transformers; 120 (52 percent) had SCADA. At the end of this project, 69 percent were SCADA-enabled.

### Project Features

*Goals and Objectives*

- Remote monitoring and control of the substation equipment.
- Real-time equipment and system status.
- Support of the Advanced Operating System Project, which will develop and implement three automated strategies to improve efficiency and increase reliability of electricity provided to customers:
  - Conservation voltage reduction, which slightly reduces the voltage output of a substation without affecting electrical system performance, resulting in energy savings for SMUD and its customers.
  - Volt/VAR optimization, which reduces system losses, increasing system efficiency.
  - Automatic sectionalizing and restoration, which detects faults on the distribution system and automatically switches the electrical lines in use to minimize the number of customers impacted by an outage.

*Project Features*

Key elements of the Substation SCADA Project:

- Design and modify existing electrical and communication systems
- Install SCADA system
- Install intelligent electronic devices for remote monitoring and control of substation equipment
- Install 48-volt DC power supply and communication systems

*Continued on back*

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*Benefits*

- Improved reliability and quality of service
- Improved efficiency and response time
- Improved asset management
- Reduction in lost revenue due to outages

## At-a-Glance Facts

**Start date:** April 2010

**End date:** December 2012

**Number of substation transformers to be upgraded:** 40

**Budget:** $16 million

*Milestones*

**Planning:** April 2010 – September 2010

**Procurement:** October 2010 – September 2012

**Phase 1 – civil and telecommunications construction:** May 2010 – June 2012

**Phase 2 – electrical construction:** November 2010 – December 2012


*"This project enables system operators to have hands on the pulse and heartbeat of the distribution system."*

– Manjit Sekhon, Project Manager

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# Smart Grid

## Line Automation

### Project Overview
This project will enable and support smart grid, computer-based energy-efficiency initiatives through the installation of a communication network and automated line devices on more than 160 of SMUD's circuits.

### Project Features
*Goals & Objectives*

- Remote monitoring and control of the electrical distribution system
- Real-time equipment and system status
- Support of the Advanced Operating System Project, which will develop and implement three automated strategies to improve efficiency and increase reliability of electricity supplied to customers:
  - Conservation voltage reduction, which slightly reduces the voltage output of a substation without affecting electrical system performance, resulting in energy savings for SMUD and its customers.
  - Volt/VAR optimization, which reduces system losses, increasing system efficiency.
  - Automatic sectionalizing and restoration, which detects faults on the distribution system and automatically switches the electrical lines in use to minimize the number of customers impacted by an outage.

*Design and Features*
Key elements of the Line Automation Project include design and installation of:

- A communication network for two-way communication with automated line devices
- On 118 12-kilovolt circuits: Capacitor banks, pad-mount, motor-operated switches, and reclosers all enabled with two-way communication
- On 18 21-kilovolt circuits: Reclosers enabled with two-way communication
- 44 motor operators on 25 69-kilovolt circuits (subtransmission)

*Continued on back*

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*Benefits*

- Improved reliability and quality of service
- Improved efficiency and response time
- Improved asset management
- Reduction in lost revenue from outages

*"Distribution automation is what makes the smart grid 'smart.' "*

— Joseph McGuire, Project Manager

## At-a-Glance Facts

**Start date:** April 2010

**End date:** July 2013

Automation of 118 12-kilovolt circuits (18 percent of the distribution system)

Automated switches on 25 69-kilovolt circuits (44 percent of subtransmission)

Automated switches on all feasible 21-kilovolt circuits (100 percent of the 21 kv service area).

*NOTE: The Network is very different from the 21 kv system.*

**Budget:** $28 million

*Milestones*

**Standards development and equipment procurement:** April 2010 – January 2012

**Installation of equipment:** April 2013

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# Smart Grid

## Conservation Voltage Reduction and Volt/Var Optimization

### Project Overview

The CVR/VVO project implements a model-based conservation voltage reduction (CVR) and a volt/var optimization (VVO) strategy to reduce line losses and boost the efficiency of the distribution system.

### Project Features

This project uses automated line capacitor banks and the communication network installed under the line automation project and the updated substation equipment in the Supervisory Control and Data Acquisition (SCADA) retrofit project.

SMUD modifies and leverages its existing capacitor control software for VVO and develops and implements CVR control capability within the existing Siemens SCADA system. The VVO software and line capacitor banks monitor and correct power factor on the distribution grid, decreasing line losses. Minimizing line losses enables system operations to initiate CVR, which lowers the voltage output at the substations while maintaining minimum voltage requirements. The lower voltage levels result in lower energy output at the substation and can mean lower energy consumption for SMUD customers.

We worked with the Electric Power Research Institute (EPRI) to develop the 2013 test plan. The project evaluates both summer and winter energy savings. These results are used to recommend how to best leverage the control strategies in the future.

*Goals & Objectives*

- Use CVR to reduce the voltage output at the substation, resulting in energy savings for SMUD and our customers
  - Test 2 percent voltage reduction at the substation
- Use VVO to reduce system losses, increase system efficiency, and provide voltage support
- Maintain the power factor as close to unity as possible

*Continued on back*

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***Benefits***

- Improved system efficiency
- Increased energy savings
- Reduced customer energy bills

## At-a-Glance Facts

- Implemented on 18 percent of the distribution system
- **Total budget:** $2.8 million [includes cost for both CVR/VVO and Automatic Sectionalizing and Restoration (ASR)]

***Key Milestones***

- Implementation from April 2010 to June 2013
- Completed summer testing to validate control strategy: Summer 2011
- Evaluation through December 2014

*"The advanced operating system is the brain that centrally controls substation and line devices to help SMUD operate its system more efficiently and reliably."*

— Malissa Ellis, Project Manager

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# Smart Grid

## Automatic Sectionalizing and Restoration

### Project Overview

The automatic sectionalizing and restoration (ASR) project will detect faults on the distribution system and control automated switching devices to isolate the fault.

### Project Features

This project uses automated switching devices and the communication network installed under the line automation project, and the updated substation equipment in the Supervisory Control and Data Acquisition (SCADA) Retrofit project.

SMUD will develop and implement the ASR control strategy to centralize control of automated switching devices and enable the system to "self-correct."

We'll develop a test plan to evaluate the ASR control logic and quantify the reliability impact. The test plan has three components:

- ASR lab simulation test: Simulation and validation of the ASR control logic under various scenarios for three basic feeder pair configurations, end-to-end, in a laboratory setting.
- Theoretical reliability improvement analysis: Review five years of historical outages and determine improvement in the System Average Interruption Duration Index (SAIDI, a measure of reliability) if the remotely controlled, automatic line devices and ASR had been implemented.
- Real-time performance evaluation: Documentation of SAIDI improvement based on actual performance of feeders equipped with remotely controlled automatic line devices and ASR.

*Goals & Objectives*

- Utilize ASR on upgraded circuits to detect faults on the distribution system and perform automated switching to minimize the number of customers impacted by an outage
  - Isolate the fault and restore power to most customers in less than a minute
  - Improve SAIDI on upgraded circuits

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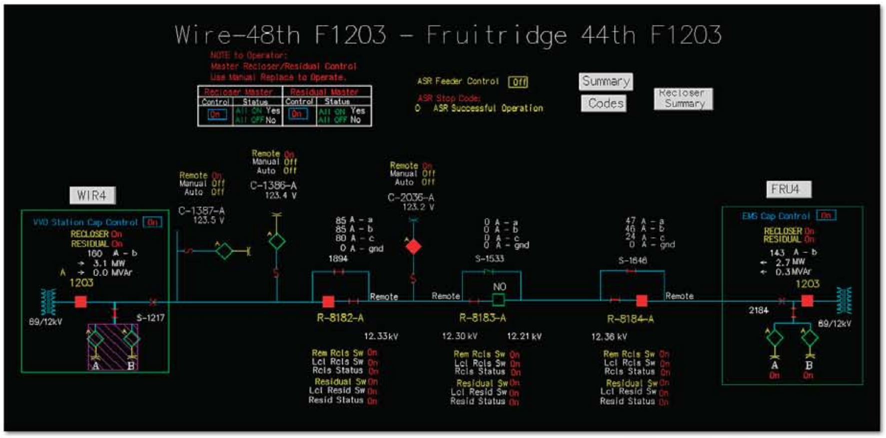


*ASR Feeder Pair EMS One-Line screen*

***Benefits***

- Improved restoration process efficiency
- Improved system reliability

## At-a-Glance Facts

- Implemented on 18% of the distribution system
- Total budget: $2.8 million (includes cost for both CVR/VVO and ASR)

***Key Milestones***

- Implementation runs from April 2010 to December 2013
- Evaluation through December 2014

*"The advanced operating system is the brain that centrally controls substation and line devices to help SMUD operate its system more efficiently and reliably."*

— Malissa Ellis, Project Manager

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## Situational Awareness and Visual Intelligence (SAVI)

### Project Overview

Situational Awareness and Visual Intelligence, or SAVI, will give an in-depth view of the distribution system by overlaying information from many sources. It will help operators get hands-on experience with an array of scenarios. The project also includes procurement of the audio/visual equipment that will display Smart Grid technologies at the new East Campus-Operations Center.


### Project Features

- Procuring and installing software.
- Integration with –
  - Geographic Information System (GIS) Oracle, Pi, Lightweight Directory Access Protocol (LADAP)/Active Directory;
  - Third party services like the National Oceanic and Atmospheric Administration (NOAA), Oracle Locator;
  - Enterprise Service Bus (ESB), Structured Query Language (SQL) Server, SAP, and Excel spreadsheets.
- New equipment includes –
  - a 30-foot by 9-foot LED heads-up display,
  - 55-inch monitors to view the SAVI dashboard,
  - 30-inch monitor to view the Outage Management System (OMS),
  - four 24-inch monitors to view and control Distribution Automation (DA) equipment in EMS,
  - new Redhat Linux Workstations and corporate desktops, and
  - a 70-inch touch table

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*Goals & Objectives*

The goal is to provide SMUD's Distribution System Operations greater ability to synthesize information and visualize data in a timely manner.

*Benefits*

The system offers a single platform from which to see and analyze information from several sources and observe trends over time. It applies the data to existing distribution network situations and gives operators better insight and more details.


## At-a-Glance Facts

The project ran from March 1, 2012 to April 22, 2013

**Total budget:** $3.2 million

**Information displayed to the operators will include:**

- Current and historical substation loads
- Outages
- Feed-in tariff photovoltaic locations and generation
- Forecasted photovoltaic generation potential
- Emergency visualization
- Historical, current and forecasted weather

**Planning:** March to August 2012

**Procurement:** August 2012

**Integration:** March 2013

**Project End:** April 2013

*"The Smart Grid enables us to do what some customers thought utilities always could do."*

— Michael Greenhalgh, Project Manager

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# Smart Grid

## Outage Management System Upgrade

### Project Overview

The Outage Management System Upgrade project updates the core technology for all computer-based remote control and automation technologies used to make electrical delivery systems more efficient. The project allows distribution system operators to view supervisory control and data acquisition information collected through automated line devices and upgraded substations within the outage management system. The upgrade also enables more efficient integration with other SMUD systems through Web services.

### Project Features

- Upgraded the outage management system to Intergraph's InService 8.2
- Upgraded the mobile application used by distribution field forces
- Integrated SCADA through an inter-control center communications protocol gateway
- Developed an electronic wall map

*Goals & Objectives*

- Upgrade to a newer version of the outage management system and iMobile application
- Enable distribution system operators to view supervisory control and data acquisition (SCADA) information within the outage management system
- Enable the development of an electronic wall map to replace the paper wall map

*Benefits*

- Improved system functionality
- Integration with SCADA
- Improved system accuracy as a result of removal of the paper wall map (reducing to one system of record)

### At-a-Glance Facts

**Start date:** April 2010

**End date:** April 2013

**Budget:** $3 million

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**Procurement:** April 2010 – September 2011
**Upgrade development system:** November 2010
**Upgrade quality assurance:** August 2011
**User training:** September 2012
**Outage management system upgrade:**
September 2012
**Development of electronic wall map:** April 2013
**SCADA/outage management system integration:** April 2013

*"This critical project upgrades the core technology for all smart grid applications."*
— Teresa Klostermann, Project Manager


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# Smart Grid

## Enterprise Data Historian (PI)

### Project Overview

The Enterprise Data Historian project upgrades the OSIsoft LLC PI System, which allows real-time management and organization of meter data. The project supports SMUD's smart-grid capabilities, which use computer-based remote control and automation to make electrical delivery systems more efficient.

### Project Features

***Goals & Objectives***

Provide our Grid Planning and Operations group greater insight into load demands at the meter.

***Design and Features***

The Project upgrades SMUD's license with OSIsoft LLC to an enterprise agreement in support of the SmartSacramento® Distribution Automation Project. The upgrade includes software updates, 24/7 technical support, bug fixes, and replacement of software to upgrade the current PI System (data management solution). As part of the agreement, SMUD will implement new infrastructure to host PI 2012, Asset Framework 2012, and Smart Connector in order to retrieve and store meter data.

Key elements of the project are:

- Contract execution.
- Procurement and installation of hardware and software.
- Integration with Silver Spring Networks UtilityIQ (smart grid application) for capturing and retaining meter kilowatt hours and kilovolt-amperes reactive.

***Benefits***

The system will analyze load at the meter for better power quality management and create a foundation for faster adjustments and decision-making for conservation voltage reduction/volt-VAR optimization (electricity-use reduction strategies).

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## At-a-Glance Facts

**Start date:** May 1, 2012

**End date:** April 22, 2013

**New infrastructure** includes 14 virtual servers and two blade servers running Windows 2008 R2 Service Pack 1 to host PI System, Asset Framework, and an interface node

**Information captured from UtilityIQ:**

- Kilowatt hours
- Kilovolt-amperes reactive
- Voltage

**Frequency:** hourly

**Budget:** $2 million

*"The smart grid enables SMUD to do what customers thought we always could."*

— Michael Greenhalgh, Project Manager

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# Smart Grid

## Outage Communication Project

### Project Overview

The goal of the project is to use phone notifications to alert and update customers about power outages, including when power is estimated to be restored and confirmation that electric service has resumed.

The pilot targets customers during outages lasting for long periods of time. It will test the performance of call messaging, the timing of the calls, the accuracy of the estimated restoration time, the overall customer experience, and any impacts on the volume of calls to the Contact Center.

### Project Features

The system will use automated phone voice messages to alert customers of a power outage, following up with a call indicating the estimated time of power restoration, and finally, a call to confirm that service has been restored.

#### *Goals & Objectives*

This program will allow SMUD to try out and refine performance and accuracy of phone messaging technology and time estimation models, and proactively inform customers of outages and updates on restoration.

#### *Benefits*

Streamlining up-to-date notification of outages, expected restoration and resumption of power will improve customer service and could reduce calls to the Contact Center.

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## At-a-Glance Facts

- Project duration: September 2011 to May 2013.
- Total budget: $600,000.
- Calls made from May 2012 to December 2012:
  - Initial outage calls: 14,772
  - Estimated restoration calls: 801
  - Restoration confirmation calls: 71,522
  - Total calls: 87,095
- January 2012: Obtained cyber security approval.
- February 2012: Amended automated phone service contract.
- March 2012: Finalized outage messages, with approvals, and finalized business requirements.
- May 2012: Pilot program launched.
- May 2013: Moved application onto the enterprise service bus.

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# Smart Grid

## Integrated T&D Modeling Tool

### Project Overview

This project launches software for modeling the transmission and distribution of electricity, allowing SMUD to track all the benefits of the SmartSacramento® portfolio of projects. The software gives SMUD system planners a high-fidelity tool for designing and placing distributed generation systems, simulating demand response, conservation measures, energy storage and automated controls, so the overall electricity system can perform more effectively.

### Project Features

***Goals & Objectives***

The goal is to create an integrated computerized model of transmission and distribution systems for evaluating the siting, sizing, dispatch and placement of distributed energy resources. Installing new software will allow SMUD to simulate impacts on the grid of electric vehicle charging loads and from different distributed generation and demand response scenarios throughout SMUD's service area. The software will reflect the most updated and accurate view of SMUD's current loads and power delivery system. It will dovetail with SMUD's existing modeling legacy software, making the models and simulations more accurate.

***Design and Features***

*Modules of the modeling software*

- Distributed energy resource (DER) optimization, for evaluating the best placement and sizing of DER systems
- Distributed generation impact evaluation
- Photovoltaic impact evaluation
- Electric vehicle impact evaluation
- Demand response application
- Employee training

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*Benefits*

The tool allows SMUD to plug in variables from many different systems and predict the outcomes of distributed generation, energy storage and projects aimed at reducing electrical loads throughout our service area. It also allows planners to compare different technologies to find the most economically effective and highest performing, optimizing SMUD's investment dollars.

## At-a-Glance Facts

- Project runs from October 2012 to April 2013
- Project budget: $690,014

*"To assess the value of advanced distributed energy resources, utilities will need software tools such as the integrated T&D Modeling tool. This type of tool will enable system engineers and capacity planners to simulate the potential impacts and benefits from various levels of distributed generation, energy storage, demand response, and electric vehicle deployments."*

— Jeff Berkheimer, Project Manager

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# Smart Grid

## Mobile Data Terminal Replacement

### Project Overview

Field forces use specially made rugged laptop computers mounted in their vehicles. These computers are used to display our entire distribution network electronically, receive work, update outage information and provide updates on job
progress, along with other functions that improve field force productivity and availability. This project includes replacement, retrofit and installation of new mobile data terminal laptops used by our distribution field forces.

### Project Features

The project involved the evaluation, purchase and installation of rugged laptops. Appropriate software, including the upgraded mobile outage management system, was installed on the laptops prior to installation. Laptops were installed and the conversion to the upgraded system was tightly coordinated with the Outage Management System (OMS) upgrade project.

*Goals & Objectives*

- Provide the hardware needed to run the current Mobile Outage Management software
- Provide tools and equipment for increased reliability of the MDT and related systems
- Enable better support and customer service to crews
- Establish a multi-year support contract for MDT mounting hardware

*Benefits*

- Increased reliability of hardware and software
- Increased efficiency leading to faster event resolution and less down time
- Increased utilization of the Mobile Outage Management software
- Lower cost for support and maintenance

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## At-a-Glance Facts

**Start date:** November 2010

**Planning:** August 2011

**Laptop Evaluation:** December 2011

**Laptop Purchase:** March 2012

**Installation:** May 2012 - August 2012

**Conversion to new Mobile OMS:** September 2012

**End date:** December 2012

**Laptops Purchased:** 112

**Laptops Deployed:** 103 (9 spares)

**Vehicles Retrofitted:** 82

**Total budget:** $1.2 million

*"Having the right tools for the job is vital to our safety and providing our customers - both internal and external - the best customer service."*

— Ariel Cumigad, Project Manager

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# Smart Grid

## SmartPricing Options

### Project Overview

SMUD's SmartSacramento® project includes a consumer behavior study evaluating the impacts of time-based rates, enabling technologies, and recruitment methods on energy consumption and peak demand.

### Project Features

***Goals & Objectives***

SMUD's goal was to assess customer response to and seek customer acceptance of varying combinations of enabling technologies, recruitment methods, and time-based rates. SMUD is focused on the impact of customer response during peak hours and critical peak events.

***Design and Features***

With a study sample of approximately 100,000 residential customers and a test period from June 2012 through September 2013, we used three experimental designs to study customer response to pricing options:

- Randomized control trial (RCT) with delayed enrollment (i.e., "Recruit and Delay")
- Randomized encouragement design (RED) and
- Within-subjects design

In the RCT "Recruit and Delay" study design, a randomly selected group of customers from the study sample were recruited into a specific treatment (opt-in), but only half of those who are invited to participate were eligible to be exposed to that treatment for the test period, while the remainder served as a control group on the existing inclining block rate in years one and two; however, they were permitted to enroll in the offered rates after the study period ended after the second year.

In the RED study design, a group of randomly assigned customers from the study sample served as the control group and remained on SMUD's standard inclining-block (tiered) rates without any form of technology offered by SMUD. We then offered a randomly selected second group of customers from the study sample a specific treatment, "encouraging" them all to accept the offer on the opt-in basis or allowing them to reject the offer on an opt-out basis, depending upon the treatment. All of these

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"encouraged" customers were considered in the study for evaluation purposes whether they accept or reject the treatment.

The within-subjects design used no explicit control group; instead it estimated the effects of the treatment for each participant individually, using observed electricity consumption behavior both before and after becoming a participant in the study as well as on critical peak events and non-event days.

The control group selected for the RED design were used to control for exogenous effects in the within-subjects design.

***Benefits***

- Potential bill savings from dynamic pricing
- Customers own the devices during and after the pilot

*"The SmartPricing Options pilot offers time-based pricing to customers and encourages them to shift their load to off-peak hours. Combined with educational information through a variety of customer-facing applications, customers can have more control over their energy bills and help SMUD reduce peak energy demand. SMUD has been able to gain valuable information on customer perceptions and behaviors for each of the pricing plans, which will help inform rate designs and future program planning."*

— Jennie Potter, Project Manager

## At-a-Glance Facts

**Pilot Population:** Residential

**Number of Treatments:** 7

**Sample:** 100,000

**Pilot Type:** Experimental Research Design

Treatment Groups:

- Default TOU with IHD Offer
- Opt-in TOU with IHD Offer
- Opt-in TOU without IHD Offer
- Default CPP with IHD Offer
- Opt-in CPP with IHD Offer
- Opt-in CPP without IHD Offer
- Default TOU-CPP with IHD Offer

**Technology Summary:**

- In-home displays
- Web portal

**Rate Summary:**

| | |
|---|---|
| TOU: | SmartPricing Options "Summer Weekday Value Plan" |
| CPP: | SmartPricing Options "Off-Peak Discount Plan" |
| TOU-CPP: | SmartPricing Options "Optimum Off-Peak Plan" |

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# Smart Grid

## Demand Response Management System

### Project Overview

The Demand Response Management System Project (DRMS) involved installing a software platform that supported SMUD's short- and long-term need to give customers price-based and incentive-based programs to manage peak electrical loads. Key aspects of the project include:

- Procuring and installing new DRMS software on SMUD-procured servers.
- Integrating the DRMS solution into existing SMUD systems.
- Planning, developing scripts for, and executing testing of the new system.
- Supporting the deployment of the solution into a production environment.
- Training SMUD project team members and technical staff.
- Enabling commercial automated demand-response (Auto DR) functionality with SMUD's six SmartSacramento® partners: the California Department of General Services, California State University Sacramento, Elk Grove Unified School District, Los Rios Community College District, Sacramento City Unified School District, and Sacramento County.
- Enabling direct load control of residential and small-commercial air conditioners and electric vehicle chargers.

### Project Features

***Goals & Objectives***

- Build a new, highly secure system platform through which all of SMUD's demand-response activities can be managed.
- Use existing open standards to build the system.

***Design & Features***

The DRMS enables SMUD to provide demand-response functionality to customers enrolled in either price-based or incentive-based programs.

The DRMS features include:

- Wizards to create new demand-response programs that conform to a set of business rules.

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- Robust load-reduction forecasting with adaptive learning.
- Support of text message, phone, and email communication channels for program participants to receive messages.
- Support of ZigBee Smart Energy Profile v 1.1 Home Area Network devices, Open Automated Demand Response v 1.0 client devices, and broadband access via a customer gateway.
- Ability to tailor demand response events by program and by grid topology (system, substation, transformer).
- Support of the following programs: direct load control, load reduction commitment, battery storage, and critical peak pricing.
- High security.
- Capability for participants to opt out of demand-response events via devices, SMUD's Contact Center, or the Internet.
- Automated billing settlement.

***Benefits for the Customer***

- Customers can take advantage of new incentive-based and price-based demand response programs to manage energy use.
- Customers with Landis+Gyr ZigBee-enabled meters or broadband capability will have connectivity with SMUD to use new programs to manage their energy use.
- Through the Internet or Contact Center, customers can enroll, dis-enroll, and opt-out.

## Contact Information

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***Benefits for SMUD***

- One platform will manage all of SMUD's demand response activities.
- The system is built within SMUD's secure environment.
- The system is built around open industry standards, so it is not dependent upon vendor-specific protocols.
- Robust load-reduction forecasting tools can predict load reduction at all levels of the distribution system.
- The Peak Corps air conditioning load management system can eventually be retired.

## At-a-Glance Facts

**Cost:** $4.4 million

**DRMS Vendor:** Lockheed Martin

**Open Standards Supported:** Smart Energy Profile v 1.1, Open Automated Demand Response v 1.0

**Project Start:** March 2010

**Project End:** April 2013

*"The DRMS will enable SMUD to manage all its demand response in one place."*

— Craig Sherman, Senior Project Manager

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# Smart Grid

## PowerStat Pilot — 2012 (Direct Load Control)


### Project Overview

The 2012 PowerStat Pilot program evaluated the effects of three separate utility controlled strategies to reduce residential air conditioning use during times of high air conditioning usage. Each strategy had a different duration and degree of pre-cooling before the air conditioning system temperature was increased for the PowerStat-day event. A third-party load-management system triggered the testing events, and a paging communication service signaled the pre-cooling and temperature values to the customers' thermostats.

### Project Features

#### *Goals & Objectives*

The 2012 PowerStat Pilot program focused on evaluating the effects on customer comfort and electricity use (load) of different levels and durations of pre-cooling. Additionally, the capabilities of the technology involved were assessed for use in future projects and programs.

#### *Design and Features*

The design called for a random sample of 180 participants, divided into three groups. Each group experienced a particular pre-cooling strategy twice before being moved to another strategy during eight PowerStat-day events in August and September, 2012. All customers experienced all strategies to reduce any potential bias they might have against any one approach, which allowed for better evaluation of the effects.

One key feature that customers appreciated was a website they could use to program their thermostat temperatures and schedules or to opt out of a PowerStat-day event. Customers were allowed an unlimited number of event opt-outs during the study.

#### *Benefits for the Customer*

- Increased awareness, satisfaction, and engagement with direct load control programs.
- Information on how to better control their energy usage through thermostat schedules.
- Potential bill savings based on energy efficiency education.

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# Smart Grid

## PowerStat Pilot — 2013 (Direct Load Control)


### Project Overview

During the summer of 2013, the program will test three demand-response strategies using a customer-choice model. Customers will choose between incentive-based and price-based offerings. With the price-based offering, customers will also choose between having SMUD control the temperature offset or controlling the temperature offsets themselves.

The field study will create 12 conservation days in the summer during which thermostat settings will be increased by a few degrees. Participants will provide feedback on their experience via surveys throughout the year. A demand-response management system will trigger conservation days using the smart meter network and two-way programmable communicating thermostats.

### Project Features

*Goals & Objectives*

The 2013 PowerStat Pilot Program will offer residential and small-commercial customers a choice between incentive-based and price-based demand response programs. This customer-choice model will give SMUD valuable information on future program benefits and costs and will capture customer preferences. Specifically, the pilot program will seek to:

- Assess energy savings potential.
- Assess customer preferences regarding program offerings.
- Assess effectiveness of applied technology to electricity use (direct load control).
- Assess the peak-period electricity savings derived from various temperature differential (offset) values.
- Evaluate customer satisfaction with and acceptance of the program design and applied technology.

*Design and Features*

The project design calls for a random sample of up to 1,000 participants: 600 residential customers and 400 small-commercial customers with demand of 20 kilowatts or less. Since customers choose which offering they will use, there is no predetermined number of participants required for any one offering.

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- Installation of a free programmable thermostat.
- An online option to control temperature settings and thermostat schedules.
- Ability to override a PowerStat-day event via the Internet.

*Benefits for SMUD*

- Increased customer awareness, satisfaction, and engagement with direct load control programs.
- Experience with and documentation of pre-cooling and temperature offset recommendations for customers.
- Ability to provide customers with potential cost savings based on energy efficiency.
- Promotion of energy efficiency and peak-load reduction.

## At-a-Glance Facts

**Pilot population:** Residential
**Number of strategies:** Three
**Total invitations:** 14,750
**Total participants:** 175
**Field study timeline:** August through Sept. 2012

**Strategies:**

- Six-hour pre-cool of 2 degrees with 3 degree offset.
- Two-hour pre-cool of 4 degrees with 3 degree offset.
- No pre-cool with 3 degree offset.

**Technology summary:**

- Honeywell UtilityPRO one-way programmable communicating thermostat.
- Cooper Power Systems Yukon load management system and customer portal to manage thermostat temperatures, schedules, and overrides.
- American Messaging Paging Communication Service.

**Rate summary:** Residential standard rate.

*"The 2012 direct load control study results show that mild pre-cooling coupled with good insulation can significantly reduce not only peak demand but energy use throughout the day."*
*— Michael Daniels, Project Manager*

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# Smart Grid

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- Assess the peak-period electricity savings derived from various temperature differential (offset) values.
- Evaluate customer satisfaction with and acceptance of the program design and applied technology.

***Design and Features***

The project design calls for a random sample of up to 1,000 participants: 600 residential customers and 400 small-commercial customers with demand of 20 kilowatts or less. Since customers choose which offering they will use, there is no predetermined number of participants required for any one offering.

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Over twelve conservation days from June through September 2013, the demand response management system will signal customers' thermostats through the smart meter network. Participants will receive notice before each conservation day, and they will be allowed an unlimited number of opt-outs during the field study.

*Benefits for the Customer*

- Increased customer awareness of, satisfaction with, and engagement in demand response programs.
- Information on how to better control energy usage.
- Potential bill savings either through an incentive in the form of a bill credit or through a time-of-use or critical-peak pricing rate.
- Installation of a free programmable, communicating thermostat.
- Ability to manage participation in conservation days through an unlimited number of opt-outs.

*Benefits for SMUD*

- Increased customer awareness of, satisfaction with, and engagement in direct load-control programs.
- Knowledge about the types of programs customers prefer (incentive-based or price-based).
- Information on the effect of opt-outs and overrides on the load reduction potential.
- Promotion of energy efficiency and peak-load reduction.
- Testing of new load-reduction forecasting models and gaining experience to refine models to better match actual load reductions.

## At-a-Glance Facts

**Pilot population:** Residential and small-commercial

**Number of program offerings:** Three

**Total participants:** up to 1,000
Residential: up to 600
Small commercial: up to 400

**Technology summary:**

- Energate Pioneer Z100 two-way programmable communicating thermostat
- Lockheed Martin SEEload demand response management system
- Silver Spring Networks UtilityIQ and Home Area Network Communications Manager
- Landis+Gyr ZigBee-enabled smart meters
- SAP Customer Care and Services
- Intergraph Geographic Information System software
- Software AG Enterprise Service Bus
- Itron Enterprise Edition Meter Data Management System
- SMUD's My Account website feature
- TeleVox software

**Rate summary:**

- Residential standard rate
- Residential TOU-CPP (smart-pricing options rate)
- Small-commercial GSN_T (non-demand metered rate)
- Small-commercial GSN_TCPP (smart-pricing options rate)

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# Smart Grid

## Automated Demand Response (Auto DR)

### Project Overview

Automated demand response is an energy management strategy that uses Internet-based technology to signal customer equipment and facilities to make the most efficient use of energy resources and reduce overall energy use during peak periods.

SMUD is using a U.S. Department of Energy Smart Grid Investment Grant to coordinate feasibility studies and installation of automated demand response technologies at six key SMUD commercial customers, called the SmartSacramento® Partners. SMUD implemented PowerDirect℠, an Automated Demand Response Pilot Program in 2013 that included additional commercial participants.

### Project Features

***Goals & Objectives***

Program Design Goals

- Deliver a program with participation and performance parameters that
  - Offers ease of compliance
  - Encourages maximum performance
  - Gives the customer a manageable, cost-effective, high-quality settlement
  - Provides reliable and predictable energy use (load) reduction
- Integrate demand response, energy efficiency, and energy information
- Create a program platform that allows for integrating new technology and approaches into demand response
- Deliver demand response products that provide value to participants, SMUD, and potentially to the Balancing Authority of Northern California, which is responsible for reliable electrical grid operation in Northern California

Overall Goals for 2011 Through 2013

- Build infrastructure
- Engage and educate both customers and SMUD in demand response
- Learn how to develop and apply the technology to benefit both SMUD and its customers
- Determine customer load reductions from the technologies and program operating scenarios
- Implement automated demand response strategies
- Operate the program as a limited-scope pilot in 2013

***Design & Features***

Primary Market

The primary market consists of customers with greater than 300 kilowatts of electrical demand. Customers with smaller loads may be included to test other Smart Grid technologies.

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*Features*

- Four program options for customers
  - Firm Load Reduction
  - Minimum Dependable Load Reduction
  - Demand Response Pricing (critical peak pricing)
  - Voluntary Load Reduction
- Automated notification, dispatch, and settlement
- Voluntary customer participation
- Payment based on capacity and performance
- Technology incentives up to $125 per kilowatt of enabled demand response
- Enrollment in Energy Profiler Online, an Internet resource customers can use to monitor energy use and control costs

*Benefits*

Customers benefit from technology and automation that enables them to operate more efficiently and better control their energy costs.

SMUD benefits from a reliable and sustainable demand response resource that can meet energy needs for both economic and reliability requirements.

## Contact Information

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## At-a-Glance Facts

**Duration:** September 2010 through December 2013

**Pilot project operation:** June through September 2013

**Total budget:** $3,400,000

**Customer incentives:** Technical assistance provided at no charge; technical incentives of up to $125 per kilowatt of enabled automated demand response capability.

**Planned participants:** Six SmartSacramento® Partners and five to 15 additional commercial customers

**Planned automated demand response load reduction for 2013:** five megawatts

*"Automated demand response represents the future of demand response where technology provides the means to integrate demand response and energy efficiency, delivering a reliable and sustainable resource with high value for customers and SMUD."*

— Harlan Coomes, Principal Engineer



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# Smart Grid

## Partner Projects

### Project Overview

This SmartSacramento® Partner project extends a portion of SMUD's Department of Energy Smart Grid Investment Grant to SMUD's commercial customer base. The project focuses on the replacement or major refurbishment of energy management control systems in more than 100 large government and college buildings, as well as 33 secondary schools. All buildings are within multi-building campus settings. In addition, as part of their energy control projects the six partners have developed strategies for allowing automated reductions of energy consumption during peak demand periods (automated demand response).

### Project Features

***Goals & Objectives***

SMUD's vision for this project is to provide tangible benefits for commercial customers through the installation of "smart grid" control technologies. Common to each of the six partners is the design and installation of advanced energy management control systems for multiple buildings. The projects will allow partners to optimally control energy-consuming systems within their buildings. In addition, facility managers will be able to consolidate energy consumption information and alter control point settings from centralized locations for multiple buildings due to the development or enhancement of a network that links all facilities.

An important element of this project is developing and testing automated demand response control strategies for each partner. The strategies have been designed and are being tested in cooperation with SMUD. Automated demand response will allow SMUD to send a signal over the Internet to partners' energy management control systems to reduce energy use during peak use periods, when energy costs are highest, without compromising occupant comfort.

To achieve these goals, SMUD, acting as the prime agency under the Department of Energy, has partnered with some of the region's largest organizations:

- California State University, Sacramento
- California Department of General Services

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- Sacramento County
- Los Rios Community College District
- Sacramento City Unified School District
- Elk Grove Unified School District

*Benefits*

- Implemented applications for large commercial and industrial customers that can be replicated by others
- Incorporated interoperability improvements among multiple-building campus settings
- Increased understanding of energy patterns in individual buildings
- Enhanced ability to set or modify control point settings at the zone level
- Improved ability to preprogram independent equipment schedules hourly
- Ability to tie an entire population of buildings into a centralized control system with a graphical user interface
- Added new controls that optimize economizer functions and limit outside air entry and supply fan airflow during periods of limited or non-occupancy
- Installed advanced metering infrastructure as well as British thermal unit meters for chilled water flow to capture energy consumption profiles in existing buildings
- Developed an invoicing and billing system that works with a networked advanced metering infrastructure to allow one partner to bill private enterprises that manage facilities on campus and help them manage their electricity costs
- Use of direct digital controls, replacing pneumatic controls in some buildings
- Installed electric vehicle smart-charging equipment with an automated demand response capability for two partners
- Installed automated switching equipment with a supervisory control and data acquisition (SCADA) at one partner location for several key buildings

## At-a-Glance Facts

- Affects more than 100 large buildings and 33 secondary schools and 3 million square feet
- Gives tangible maintenance, operation, and energy savings to six large government / institutional customers
- Brings energy savings in excess of five percent of the current energy consumption for the participating buildings annually
- Provides SMUD more than two megawatts of potential summer afternoon load reduction
- Creates $36.6 million of overall project activity

*"Demonstrates the latest in control and communication technologies for a large population of buildings in our service area. Facility management can easily change set-points from anywhere using the Web and can view near real-time energy profiles. The bottom line is significant energy, operational, and maintenance cost savings for our partners."* — Jeff Molander, Project Manager


### Contact Information

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# Smart Grid

## Smart Charging Pilot

### Project Overview

This pilot will evaluate EV charging patterns at various times throughout the day. We will monitor pattern shifts impacted by time-of-use pricing from periods of high energy demand to periods when demand is not at its peak. SMUD has teamed with Clipper Creek to develop the first ZigBee-enabled, level-two charging station to give participating customers load management capabilities.

The project looked at two pricing plans: One that draws a charge from the home and is lumped into the monthly utility bill, and another that uses dedicated meters installed at the home by SMUD. Both are geared to encourage drivers to charge their vehicles at times when energy demand is lower, so they can get electricity priced in reduced, off-peak periods and lessen the strain on the electrical grid all the way to the transformer level.

The program also conducted market research to assess driver attitudes about vehicle charging hardware and strategies, different pricing options, and how effectively SMUD is educating the public and delivering information about electric vehicles.

### Project Features

***Goals & Objectives***

The goal of the project is to learn the preferences of electric vehicle drivers, get feedback on two new pricing plans, and measure the impact of the new ZigBee-enabled EVSEs. The pilot also aims to make drivers more aware of off-peak charging and its benefits, both to the customer and to the utility. The pilot will be a foundation for future program designs and equipment procurements.

***Design and Features***

The study places customers in one of three pricing plans featuring time-based pricing with low-cost, off-peak pricing:

- **Whole House Pricing Plan:** This is for electric vehicles charging at 120 volts. The vehicle charges are combined with the customer's residential electric bill, with reduced pricing during off-peak periods.
- **Dedicated Meter Pricing Plan with a self-managed option:** This is for customers who charge at up to 240 volts. Customers will be notified one day before a Conservation Day. The customer is expected to manage the charging of their electric vehicles by avoiding charging

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during periods when prices are much higher.

- **Dedicated Meter Pricing Plan with a SMUD-managed option:** This is for customers who charge at up to 240 volts. Charging loads for plugged-in vehicles will automatically be reduced to 1.4 kW during Conservation Day periods to reduce strain on the grid. SMUD will control the load reduction by sending a signal through the meter to a "smart" charging station. The customer will receive a notice one day before the Conservation Day.

SMUD will evaluate up to 20 Data-Only customers who charge at 120 volts on a dedicated circuit. In this group 120-volt charging patterns will be evaluated.

***Benefits***

- Lower off-peak charging prices
  - 7.4 cents (winter) and 8.3 cents (summer) per kWh for the Whole House option
  - 6 cents per kWh year-round for Self-Managed and SMUD-Managed options
- Electric vehicle charge will show separately on monthly bill for the Self- and SMUD-managed plans
- Two electric vehicle specialists will provide customer support by answering questions and analyzing and discussing usage data
- Reduced load on local transformers and the grid in general
- Reduced carbon emissions
- Promoting clean-air transportation

## At-a-Glance Facts

**Pilot population:** Residential

**Number of study groups:** 3

**Total participants:** Up to 180 electric vehicle drivers

**Pilot Type:** Research and evaluation

**Groups:**

- Up to 60 residential whole-house participants
- Up to 60 residential self-managed meters
- Up to 60 residential SMUD-managed meters

*"What will SMUD and Sacramento be like when most of the vehicles on the road are electric vehicles?"*

— Dwight MacCurdy, Electric Vehicles projects coordinator

## Contact Information

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# Smart Grid

## Smart Thermostats


### Project Overview

The Smart Thermostat pilot evaluates how self-optimizing thermostats impact energy efficiency, peak load, and customer bills. These thermostats automatically learn a customer's energy usage preferences over time and optimize performance. The thermostats will be combined with dynamic pricing and offered to customers at no cost. In addition to the field study, a laboratory study will see which features and interfaces are the most appealing and intuitive to customers.

### Project Features

***Goals & Objectives***

The Smart Thermostat pilot's goals and objectives center on evaluating customer acceptance of self-optimizing thermostats and the additional effect of dynamic pricing where rates vary due to factors such as time of use. This pilot focuses on the energy efficiency impacts of smart automation and customer behavior, as well as the impact on peak demand. The other key objectives of the study are customer satisfaction and enhanced engagement in energy literacy. This pilot seeks to learn about customer preferences related to overall thermostat design, functionality, and interface. Findings will be incorporated into future program designs.

***Benefits***

- A self-optimizing thermostat for energy efficiency that requires little customer effort
- Potential bill savings from automation and dynamic pricing
- Ownership of the self-optimizing thermostat
- Results that provide input into future program design and products that will enable the use of this new technology
- No cost to the customers

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## At-a-Glance Facts

**Pilot population:** Residential

**Number of program offers:** Five

- 200 Nest
- 200 Nest + TOU-CPP
- 200 EcoFactor
- 200 EcoFacto + TOU-CPP
- Up to 10: Allure

**Total invitations:** 24,000

**Technology summary:**

- Nest thermostat
- EcoFactor software + Computime thermostat + Digi gateway
- Allure app + Computime thermostat + Sheeva Plug

**Rate summary:** TOU-CPP: SmartPricing Options "Optimum Off-Peak Plan"

## Design and Features

The pilot design invites customers to participate in a specific offer that includes a self-optimizing thermostat, with approximately half of the offers including a dynamic rate designed to reward peak demand reduction. SMUD's third party installer will install the thermostats and leave the original thermostat with the customer. Property owners will own the new thermostats upon installation. SMUD and the manufacturer will maintain the devices during the study period.

The evaluation will measure customer satisfaction with the thermostats, service and rate, ease of use, energy efficiency, peak load, and bill impacts.

The rate design includes the TOU-CPP rate that was designed for SmartPricing Options. The rate is in effect from June 1 to Sept 30, 2013, with a weekday peak period from 4 p.m. to 7 p.m. and 12 critical peak events during the same hours. Customers will get a discount during the off-peak hours and charged higher prices during the peak and critical peak periods. Peak events will be called the day before, driven primarily by temperature. The rate is designed to reduce the system peak demand daily and on particularly high demand days.

The control, automation, and information technologies include three thermostats that optimize energy efficiency by learning from customer behavior. The products and services automate temperature and allow additional customer control via web portals and smart phone access.

- ***Nest*** is a self-contained thermostat with an occupancy sensor. Customers manually adjust temperatures during the short learning period while the thermostat learns preferences. High and low thresholds are programmed during set up. When the thermostat detects no occupancy, it resets to "away" mode. Nest is continually learning behavior and updating the schedule. Customers with Internet access can choose to activate an online account which includes enhanced controls and information, but this is not required.
- ***EcoFactor*** is a software product that can be used with a wide array of thermostats. Similar to Nest, it optimizes performance based on a customer-set schedule and learning period. Unlike Nest, there is no occupancy sensor, and EcoFactor performs the optimization in the cloud, incorporating weather data. EcoFactor requires internet access and a gateway.
- ***Allure*** uses proximity control technology to optimize energy savings. Using an iPhone or iPad Allure Mobile App, the temperature automatically adjusts when the customer is leaving and begins cooling (or heating) when the customer is returning home. Customers can customize their temperatures and proximity threshold, optimizing comfort.

### Contact Information

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# Smart Grid

## Low-income Weatherization

### Project Overview

Customers with limited incomes can be particularly affected by spikes in their electric bills. We are piloting a program aimed at maximizing smart meter technology to interact with these customers so they can reduce their energy use. The program takes advantage of existing weatherization audits and includes educating customers on how to view and evaluate their usage. Tips on lowering bills by using self-optimizing thermostats and in-home displays (IHDs) that show real-time electricity use are provided. We'll evaluate the effectiveness of the program by looking at factors such as energy efficiency impacts, bill impacts, behavioral change and satisfaction.

### Project Features

***Goals & Objectives***

Goals and objectives center on enhancing the existing weatherization audit program by adding new energy management tools. Two of the groups use technology and systems from other pilots: Smart Thermostat and In-Home Display (IHD) Check-Out. Additionally, some customers will receive training on how to read our online energy graphs that show hourly, weekly and monthly usage and costs. SMUD is focused on the energy efficiency impact of smart automation and customer behavior resulting from energy education. Customer satisfaction and enhanced engagement in energy literacy are key objectives.

***Design & Features***

This pilot project calls for using the weatherization audits already in SMUD's portfolio and smart grid technology to augment the help we give to limited-income customers. All customers in the project will be invited to receive a weatherization audit, while three of the groups will receive one of the additional measures described above.

Customers who receive the Nest thermostat will participate in the program for one year. Those receiving training on SMUD's online usage graphs will complete their participation obligation by installing any of the recommended energy assessment measures. Those who receive an in-home display will return it after two months via mail

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when their check-out period has ended, concluding their participation in the pilot. All participants will be asked to participate in market research efforts during the year.

SMUD's contractor will install the thermostats, leaving the original thermostat with the customer. Property owners will own the new thermostats upon installation. SMUD and the manufacturers will maintain the devices during the study period. The audit, equipment, service, and installation are provided at no cost to the customer. We will measure: customer satisfaction with the devices, tools, and service; ease of use; energy efficiency; and bill impacts.

Control, automation, and information technologies include thermostats, CDs and online videos, and in-home displays.

The in-home displays and online energy graphs facilitate customer education on consumption (real-time and day-delayed) and enable customers to better manage their electricity bills through improved understanding of electricity consumption patterns of the home, appliances and equipment. Specific devices include Power Tab™ in-home displays produced by Energy Aware.

Some customers will receive a Nest thermostat that optimizes energy efficiency by learning from customer behavior. Nest is a self-contained thermostat with an occupancy sensor. Customers manually adjust temperatures during the short learning period. High and low thresholds are programmed during set up. The thermostat resets to "away" mode when it detects no occupancy in the home. Nest is continually learning behavior and updating the schedule. Customers with Internet access can choose to activate an online account which includes enhanced controls and information, but this is not required.

***Benefits***

- Bill savings from education, automation and weatherization measures
- Self-optimizing thermostat ownership
- Weatherization measures installed in the home
- Energy efficiency education that helps customers manage their energy usage
- No cost to customers

## At-a-Glance Facts

**Pilot population:** Residential
**Total invitations:** 6,000
**Target participants:** 628
**Pilot type:** Research and evaluation
**Technology:**

- Online usage training video
- Nest thermostat
- Energy Aware Power Tab™ in-home display

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# Smart Grid

## In-Home Display Checkout


### Project Overview

SMUD's In-Home Display Checkout pilot will offer residential and small business customers the chance to borrow technology to learn about their whole-house electricity consumption and its impact on their SMUD bills. In-home displays will be available for a two-month loan from public libraries or directly from SMUD via the U.S. Postal Service.

The pilot will evaluate the following:

- Customer interest in and satisfaction with in-home displays,
- SMUD's ability to provide and enable installation of third-party home area network equipment, and
- The subsequent impact on customer bills.

### Pilot Features

***Goals & Objectives***

Goals and objectives center on customer acceptance of and response to whole-house electricity consumption and cost information provided in near real-time. SMUD is focused on the energy-efficiency impact of customer behavior in response to readily accessible cost and electricity-usage information.

Additional objectives are customer satisfaction and enhanced energy literacy.

This pilot also seeks to explore options for enabling third-party distribution of home-area-network equipment that works with SMUD's smart grid network and to understand the challenges and options for future programs and partnerships.

***Design and Features***

The design allows customers to borrow an in-home display for two months. Customers can borrow it from SMUD directly or borrow one from a public library. If the display is checked out directly from SMUD, we will prepare it for use and ship it to the customer, sending prepaid return packaging. Customers who check out the display from the library will contact SMUD to prepare the display for use (done over the phone) and will return the device directly to the library. The customer's data will be deleted from the display

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upon its return.

For small commercial customers, energy specialists will deliver the device during scheduled energy audits, or the customer can borrow one from a public library.

There is no cost to customers, and SMUD's Residential Services staff will support their needs. The evaluation will measure customer satisfaction with the pilot, ease of use, and resulting energy efficiency.

***Benefits***

- No cost to the customer
- Real-time consumption and cost information
- Potential bill savings from behavior change
- Increased energy literacy

## At-a-Glance Facts

**Pilot population:** Residential and small commercial customers

**Number of test group types:** Four

**Total invitations:** Open to all residential and small commercial customers

**Pilot type:** Proof of concept

**Groups:**

- 300 units through direct checkout via U.S. Postal Service
- 25 units (150 for second phase) for checkout via Sacramento Public Libraries
- 150 units through the Energy Insights Weatherization Pilot Program
- 50 units for distribution during small commercial energy audits

**Technology summary:**

- Energy Aware Power Tab In-Home Display
- Digi XBee ZB Smart Energy Range Extender

**Rate summary:**

- No new rates are offered in this pilot
- Rates displayed will not be customer-specific. The most common rates will be used for educational purposes and customer tiers will not change

*"Most people in the industry have given up on in-home displays, believing customers quickly grow bored with them. Who wants to spend over $100 on a device that will end up in the junk drawer after a month? This pilot program gives customers the opportunity to try out the technology with no cost and no strings attached."*

— Bryan Serinese, Project Manager

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